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ANTHROPOLOGICAL SOCIETY OF WASHINGTON

SPECIAL PAPERS

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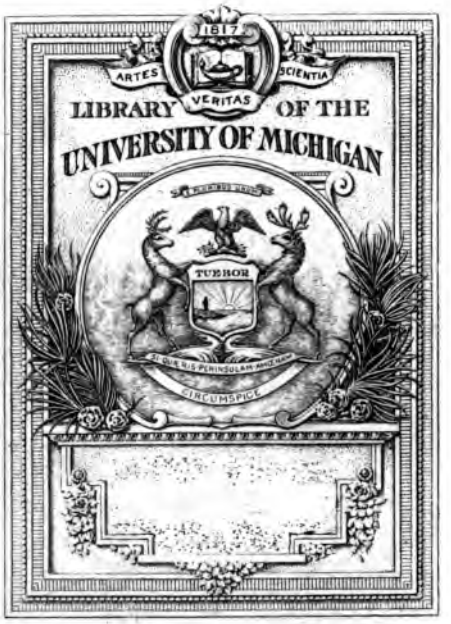
STATUS OF THE MIND PROBLEM

BY

LESTER F. WARD

PART OF A COURSE OF LECTURES PREPARED UNDER THE AUSPICES OF THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON AND DELIVERED IN THE UNITED STATES NATIONAL MUSEUM

WASHINGTON
1894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STATUS OF THE MIND PROBLEM.*

By LESTER F. WARD.

There is a revival of interest in the study of the mind. A revival, I say, because it would seem that for nearly half a century the world had dropped the study of mind, and devoted itself to the study of life. For all the centuries that preceded the scientific era, mind was almost the only subject that engaged the attention of thinking men. Not to speak of the ancients or of medieval writers, the seventeenth century was the age of Hobbes, Descartes, Spinoza, Locke, and Leibnitz, while the eighteenth was that of Berkeley, Hume, Reid, and Kant. The German and Scottish schools, under the lead of Fichte, Hegel, and Schopenhauer, and of Stewart, Brown, and Hamilton, witnessed the ebb of the great psychic tide during the first third of our own century; and although the last-named of these great metaphysicians had for his motto the words, "On earth there is nothing great but man, in man there is nothing great but mind," he was unable to prevent the world from plunging enthusiastically into the almost exclusive study of the animal and of matter. Metaphysics was abandoned, and henceforth whatever attention was given to mind was applied to its physiological side and named *psychology*. But, as already remarked, the thought of mankind has for the past fifty years been chiefly concentrated upon the problems of biology. That domain has been immeasurably enriched. First the forms of life were marshaled and scientifically classified, then the laws of their development were worked out, and finally their tissues claimed attention, as made up of various arrangements of the universal biological unit, the cell. And now it would seem that even the histological stage is past, and thought is being centered on the constitution of the cell itself—especially of the germ cell, and biologists are deep in the problem of the ultimate physiological unit or bearer of hereditary tendencies—call it *gemmule*, *plastidule*, *biophor*, or what not—in short, the problem of heredity.

But in the midst of this mad strife to compass the solution of the life problem the world has, as it were, unintentionally, and in spite of itself, again encountered the mind problem. It has discovered *protoplasm*, "the physical basis of life," and learned that this is the essential constituent of nerve tissue, the physiological basis of mind. It

* A Saturday lecture delivered in the lecture-hall of the U. S. National Museum, under the auspices of the Anthropological Society of Washington.

Spec. Pap. A. S. W., vol I.—No. 1.

has found the point to which life and mind converge, or rather, from which they diverge, and thus laid the foundation for a study of mind as a natural outgrowth of a knowledge of the body. This method of investigating the mind is as hopeful as the old metaphysical method, which contemplated it as an uncaused and foundationless entity, was hopeless, and it is obviously this hopefulness which has produced the modern revival of interest in the study of mind of which I have spoken. As a matter of fact, we have already a large and fully equipped school of experimental psychology, and there is probably no department of science to-day in which more rapid progress in the knowledge of phenomena and laws is being made. We are, it is true, still in the primary stage of observation, experimentation, and accumulation of facts, but the broader minds are already at work upon the results, and there is great promise for the future of the science of mind.

It is not my purpose to attempt any enumeration of the substantial gains to psychology that have resulted from the modern method of study, much less to set forth the nature of these methods. Both of these classes of information are accessible to those who take the trouble to scan the rapidly growing literature of the science. The task I have set myself is a much simpler one, but nevertheless one which is attended with difficulties—the task, namely, of stating the general problem, which, as it seems to me, our present knowledge of the mind presents for solution. This problem involves the two questions: What is mind? and, Whence comes it?—the nature and the origin of the mind.

The older philosophies restricted the notion of mind to what we now designate as the intellect, or at most to the intellect and the senses, by means of which it was seen to communicate with the outside world. The feelings were not supposed to be any part of the mind. Certain authors, notably Spinoza, treated the affections exhaustively, but not as a preparation for the study of mind. These and the will were considered in connection with the study of ethics. By most authors the emotions and passions were looked upon as something bad, to be restrained or suppressed, while the will was invested with divine attributes, that is, with original or underived powers. There was no lack of treatises on the soul, but neither was this regarded as any part of mind. It was independent of both mind and body, and always figured in the domain of religion.

Modern psychology, as we have seen, connects the mind with the body, but it also expands the conception of mind so as to include the feelings, the will, and also the soul. A common order of treatment is to unite the senses and the intellect into one great group of psychic phenomena, and the emotions and the will into another. Even this may be shown to be illogical, and it is beginning to be recognized that the mind has no distinct departments or faculties, but is one complex group of connected phenomena. And, curiously enough, all attempts to find a single principle or ultimate fact underlying and characterizing the

entire product have led in the direction of feeling and not of thought as the real basis of the mind. Indeed, it is now boldly maintained that thought itself, and every state of consciousness, is a feeling. And yet I think it can be successfully contended, theoretically at least, that sensation and perception are distinct things; that feeling and thought are in a sense the opposites of each other, not, indeed, independent, but, as it were, the obverse and reverse of one and the same coin. We can abstract the sensation in many cases from the knowledge that it gives, and we can and habitually do ignore the feeling and attend solely to the thought. Still, feeling is the primary fact, and no attempt to arrive at the nature of mind can succeed through the study of thought alone.

In predicating the dependence of mind and body, one of the first precautions to be taken is that against predicating their identity. That every mental fact corresponds to a physiological fact as its antecedent, or at least its necessary concomitant, is now a generally accepted truth. There is not a psychologist nor a physiologist who holds that the mental fact and the physiological fact are one and the same thing. The question as to the exact nature of the connection between these two facts may be regarded as the leading problem of psychology to-day. It is therefore fitting that I should offer a few thoughts on this problem.

We are constantly hearing about the "mystery of mind," and when we inquire closely what this means we usually find that it is just this question of the real relation of mind to body. All admit that there is no resemblance between mind and body, and it is the overwhelming consensus of opinion that the connection between them is utterly inexplicable. I shall not refer to those authors who look upon the body as something essentially base, and despise matter. I shall confine myself to an exposition of the views of men who have devoted their lives to the study of matter, either in the inorganic world or as organized in the bodies of living organisms, and who have taught us the dignity and purity, I had almost said, the divinity, of the material world. Said Prof. Tyndall:

"The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought, and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass by a process of reasoning, from the one phenomenon to the other." *

Mr. Herbert Spencer is on record in many forcible passages. He says:

"Though accumulated observations and experiments have led us by a very indirect series of inferences to the belief that mind and nervous action are the subjective and objective faces of the same thing, we re-

* *Report Brit. Assoc. Adv. Sci.*, Part II, Transactions, p. 5. Presidential address before Section of Mathematics and Physics, of the British Association for the Advancement of Science; Norwich meeting, 1868.

main utterly incapable of seeing, and even of imagining, how the two are related. Mind still continues to us a something without any kinship to other things; and from the science which discovers by introspection the laws of this something, there is no passage by transitional steps to the sciences which discover the laws of these other things." *

And again:

"Can the oscillation of a molecule be represented in consciousness side by side with a nervous shock, and the two be recognized as one? No effort enables us to assimilate them." †

Prof. Joseph LeConte holds views equally pronounced:

"I know," he says, "that much, very much, has been done recently which to many seems to identify psychology with brain physiology, and mental and moral phenomena with brain changes; and that much more will be done in the same direction. But when all is done,—all and more than we can possibly now imagine, we shall be no nearer the solution of the mystery of the relation of brain changes to mental phenomena than we are now. It is not a mystery which lessens, but only increases with knowledge. I do not hesitate to say that with an absolutely perfect science it would still be there, or even come out in still sharper relief. A vibratory thrill passes along a nerve-fiber, brain atoms are agitated by certain vibrations or oxidations, or what not—and, lo! there appear consciousness, thought, emotion. Aladdin's lamp is rubbed, and, lo! the Genii appear. There is just as much comprehensible causal relation between the two sets of phenomena in the one case as in the other." ‡

Prof. Ladd, in his Physiological Psychology, § treating of memory, remarks:

"In the study of perception psycho-physics *can* do much towards a scientific explanation. - - - But for that spiritual activity which actually *puts together* in consciousness the sensations, it can not even suggest the beginning of physical explanation. Moreover, no cerebral process can be conceived of, which—in case it were known to exist—could possibly be regarded as a fitting physical basis for this unifying *actus* of mind. Thus also, and even more emphatically, must we insist upon the complete inability of physiology to suggest an explanation for conscious memory. - - - It is this peculiar claim in consciousness which constitutes the *essence* of an act of memory; it is this which makes the memory wholly inexplicable as a mere persistence or recurrence of similar impressions. It is this which makes conscious memory a spiritual phenomenon, the explanation of which, as arising out of nervous processes and conditions, is not simply undiscovered in fact, but utterly incapable of approach by the imagination. When, then, we speak of a physical basis of memory, recognition must be made of the

* Principles of Psychology: sec. 56. Am. Ed., 1873, vol. I, p. 140.

† *Ibid:* sec. 62. Vol. I, p. 158.

‡ "Relation of Biology to Sociology;" p. 4. (Reprint from *The Berkeleyan* for May, 1887, vol XXIII, p. 123.

§ Part II, chap. X, sec. 23; pp. 556, 558.

complete inability of science to suggest any physical process which can be conceived of as correlated with that peculiar and mysterious *actus* of the mind, connecting its present and its past, which constitutes the essence of memory."

Finally, Prof. William James, in his great work on the Principles of Psychology, rings new changes on this widely accepted doctrine of the mystery of mind:

"Everyone admits" he says "the entire incommensurability of feeling as such with material motion as such. 'A motion became a feeling!'—no phrase that our lips can frame is so devoid of apprehensible meaning. Accordingly, even the vaguest of evolutionary enthusiasts, when deliberately comparing material with mental facts, have been as forward as any one else to emphasize the 'chasm' between the inner and the outer worlds."*

And after a long discussion of all the possible theories of the connection between mind and body, he concludes:

"I confess, therefore, that to posit a soul influenced in some mysterious way by the brain-states and responding to them by conscious affections of its own, seems to me the line of least logical resistance, so far as we yet have attained. - - - We must - - - ask ourselves whether, after all, the ascertainment of a blank unmeditated correspondence, term for term, of the succession of states of consciousness with the succession of total brain-processes, be not the simplest psychophysic formula, and the last word of a psychology which contents itself with verifiable laws, and seeks only to be clear, and to avoid unsafe hypotheses." †

These expressions may be taken as furnishing a fairly correct idea of the prevailing sentiment among those most entitled to be heard upon the relations between physiological processes in the nervous system and states of consciousness in the mind, or as Prof. Huxley has put it, between *neurosis* and *psychosis*. It would of course, be hopeless, even were any one so disposed, to attempt to stem such an irresistible tide of opinion. Such an attempt is very far from being my purpose, and no one is more free than I am to admit the essential mystery of mind. I propose simply to call in question, first the *necessity*, and secondly, the *propriety*, of emphasizing in such a vehement, and I might also say, gratuitous manner the fact that we are, and perhaps must always remain, profoundly ignorant of the primary and essential nature of mind.

First, then, as to the necessity for the constant and repeated confession of this ignorance. As it comes so largely from men who are dealing directly with one or another aspect of the material world it is calculated to produce upon the rest of mankind the impression that they are afraid of the charge of materialism, and are trying to atone in this way for the sin of devoting their lives to the study of matter,

* Principles of Psychology, vol. 1, p. 146.

† *Ibid.*, vol. 1, pp. 181, 182.

the investigation of physical phenomena and the tissues of the animal body. The way in which physicists and anatomists vie with metaphysicians and theologians in repelling even the imaginary insinuation that they accept the theory of a direct connection of mind with body suggests a feeling on their part that the latter are right in ascribing to matter and the flesh qualities that are low, earthy and base. Notwithstanding the fact that anatomists, histologists, and especially the students of the brain and nervous system have brought to light the wonderful complexity, beauty, and perfection of the animal body, and shown to what extraordinary degrees of development and refinement organization is capable of raising the materials with which it deals, there is still manifested an abhorrence at the idea that so astonishing an organ as the brain can even be the *cause* of feeling and thought. The most that will be admitted is that the latter are in some "mysterious" way correlated with the former, that they are their regular concomitants, that there is some preëstablished, or at least, unexplained and unexplainable harmony between them. Prof. James, as we have seen, is loth to go even this far, and contents himself with predicating, in the most purely positivistic way, a "blank unmediated correspondence, term for term, of the succession of states of consciousness with the succession of total brain-processes."

Although no one supposes that there is any resemblance whatever between a state of consciousness and a brain process, all admit that the latter accompanies and corresponds to the former. Few will go so far as to concede a difference of time in the sense that would make the one the antecedent of the other, but some, like Mr. Spencer, maintain that they are the opposite sides, the subjective and objective correlates, of one and the same phenomenon. We are strongly reminded of the time when men's attention was chiefly drawn to the discussion of the question how the mind was related to the external world, all denying that there was any resemblance between the real world and the world which the mind perceives, and many insisting that there was no relation whatever between them. Some denied the existence of an external world altogether and held that everything was subjective, or wholly in the mind; while others went further and more logically denied the existence of the mind also, and arrived at pure nihilism. Finally Leibnitz brought forward his theory of the existence of both the self and the not-self which were wholly unlike and unrelated, but brought into perfect correspondence, such as they seemed to possess, by a supernatural agency at work from the beginning and resulting in a "preëstablished harmony." Unsatisfactory as such a doctrine now seems, it was widely accepted in that less critical age. Speculations of this kind are now relegated to the department of psychology denominated *epistemology*, and thought is centered upon the relations of the mind, not to the outer world but to the inner world, the brain and nervous system. And in the discussion of this question we seem to

have reached the Leibnitzian stage in which the world is satisfied with the doctrine of a preëstablished harmony. But is it going to remain satisfied with this? I think not.

As the question is one of reasoning from general facts within the possession of all, it is not necessary that one be a great high priest in the science of mind to entitle him to speak with regard to it. While therefore denying to any the right to speak *ex cathedra*, and making no claim to be believed beyond that which belongs to the inherent reasonableness of what I say, I venture to suggest a possible way out of the somewhat humiliating, not to say ridiculous, position in which we seem to be at the present time in relation to the mind problem.

The explanation that I would offer is none other than the simple assumption that the phenomena of mind stand in the same relation to the brain and nervous system that all other phenomena stand to the substances that produce them,—in a word, that the mind is a property of the organized body. The body, organized as it is, with its nervous system and great central ganglion, manifests the properties which it possesses by virtue of its constitution in precisely the same way that all other substances manifest the properties resulting from their inherent nature or constitution. Every substance differs from every other in both its constitution and its properties, and no chemist doubts that the properties of any substance are due to its peculiar constitution; that is to say, the constitution of a substance is the cause of the properties it manifests.

Now, there is an important law governing the properties of substances. It may be briefly formulated by saying that the properties of substances are more active in proportion as their molecular constitution is more complex. The properties of the simpler chemical elements are very inert, those of inorganic compounds are usually much less so, their activities increasing roughly with the degree of composition, and when the organic compounds are reached we find that many of them have very active properties. The law holds for the various grades of organic compounds as we pass from the less to the more complex. The vegetable alkaloids and organic bases that furnish most of the febrifuges, narcotics, and toxics, such as quinine, narcotine, strychnine, etc., are very complex substances and possess relatively large molecules into which carbon, hydrogen, nitrogen, and oxygen all enter.

Another important law of what may be called chemical development, that is, the progress from the simpler to the more complex substances, is that increase in complexity is accompanied by decrease of stability. It is now generally believed that the chief distinction between what are called the chemical elements, which were once supposed to be the ultimate units of matter, and the inorganic compounds, is that the former are so much more stable that, unlike the latter, we are unable, by any means thus far devised, to separate them into any simpler com-

ponents. They may have been formed at a time in the history of the solar system when temperatures prevailed that were higher than can now be artificially produced. Again the distinction between organic and inorganic compounds has broken down all along the line through the artificial production of so many of the latter, formerly supposed to be formed only in the alembic of organic life. But it is here that we find the greatest instability. When we rise above the organic bases of which I have spoken in the degree of chemical complexity, we encounter a group of which the molecules are relatively enormous, so large and complex, indeed, that it often becomes impossible to write their chemical formulas with any degree of certainty. These are the albuminous compounds, and the molecule of albumen itself has been estimated to contain no less than 679 equivalents, which, reduced to the standard of the hydrogen atom, would equal 4,870 of these smallest known chemical units. And now, agreeably to the law stated, we find that the substances of this group are characterized by correspondingly great instability. As a consequence of their exalted structure their molecular activities are far more extensive and varied than those of simpler bodies. One of the principal modes in which they manifest their activities is that which is called *isomerism*, whereby a substance, without any change in the nature or number of its molecules, but by some little-understood rearrangement of them, assumes a different aspect and becomes to all intents and purposes another substance.

I will ask your patience while I very briefly state one additional principle of chemical development, necessary to be understood before we can proceed intelligently. This is what I have called the law of *aggregation* or *recompounding*. It consists simply in the assumption that in the formation of the more complex substances out of the more simple, the molecules of the lower orders enter bodily and as units into the constitution of those of higher ones. That is, they are not, or at least not necessarily, first decomposed into their simpler elements and afterwards combined to form the higher unit, but the units of the next lower order become the elements composing the molecules of the next higher. Without delaying to give examples at the earlier stages of development, we may pass at once to the albuminous compounds and suppose that albumen, with its molecules five thousand times as large as those of hydrogen, is a compound of various forms of proteine, whose molecules are some four hundred times as large as the hydrogen atoms, and that these proteine molecules remain undecomposed and combine to give to albumen the properties that it possesses. But we have reason to believe that from the molecule of hydrogen to that of albumen the process of evolution has been uniformly the same, viz., that of compounding and recompounding, of doubly and multiply compounding; in short, it has been the process of molecular aggregation. With still higher states of aggregation, therefore, we should naturally expect still higher forms of activity, still more marked properties.

What properties ought we to expect in a substance formed by the recompounding of the albuminoids? No one could predict. While we may safely predict higher properties from higher degrees of aggregation, we have no basis whatever upon which to predict the nature of these properties. In the simplest chemical reagencies we can not foretell the result. We can not even say which of the three states of matter, the gaseous, the liquid, or the solid, the new compound will exhibit at ordinary temperatures. The invincible solid, carbon, when joined with oxygen, becomes a gas; the type of gases, hydrogen, when combined with another gas, oxygen, results in water, which is a solid at 32° Fahr.; the inert gas, chlorin, combined with the equally inert liquid, mercury, becomes corrosive sublimate, which has very active properties and in no way resembles either of its components. And so we might go through the entire list. The general truth is that chemical union results in a new substance with new properties, different from and of a higher order than those of any which have united to produce it. When the highest known chemical compounds still further combine, we ought therefore to look for something remarkable. When the largest molecules whose constitution can be determined in the laboratory form themselves into higher molecular systems, we should not be surprised if the resultant substance should be an exceedingly strange and important one. The activities of all substances up to this point are molecular, but it might well be that the new compound should possess *molar activities*. At all antecedent stages of chemical development the spontaneous activity is confined to molecules; at this new and higher stage these spontaneous activities may be able to break over these bounds and manifest themselves in the mass.

Now we have a substance—its name is protoplasm—suspected of having the origin indicated, which is capable of such spontaneous movement as a mass. This wonderful property, confined exclusively to this substance, has been given the briefer name *motility*. This astonishing substance, protoplasm, whose existence was not suspected at the beginning of this century, is now known to be an abundant product of nature, to be present in every living thing and in every part of all organic beings if such part is really alive. It is this which makes it alive. Prof. Huxley has happily called it "the physical basis of life." Not animals alone, but plants as well, have protoplasm in every living cell, and it is as active in the one as in the other. But bound up with this principle of life, and almost as a part of it, protoplasm possesses another and, if possible, still higher property. This property may be fittingly called *awareness*. Its activities are systematic and methodical. They recognize differences in their environment. As Maj. Powell, in his new psychologic terminology, would probably say, they have a "knowledge of good and evil." In a word, they *feel*. In biologic language, protoplasmic bodies send out *feelers* to explore their environment. Protoplasm is therefore not merely the physical

basis of life, it is the physical basis of mind also, and all nerve tissue which is essentially such, consists of protoplasm in some of its myriad forms. From the strictly material side, protoplasm is the essential thing in life, and it is also the essential thing in mind. There is no other element controlling either vital or psychic phenomena. When this stage of material aggregation was reached evolution ceased along this line. The new line of subsequent development has been that of *organization*, and plants and animals may be regarded simply as mechanisms for the concentration, focalization, and intensification of the inherent powers and properties of protoplasm.

To do justice to this part of the subject would require a separate lecture, but I will ask your attention to a chart* (Fig. 1) suspended upon the screen, which exhibits a section through the cortex of the cerebrum, regarded by most physiologists and psychologists as the principal organ of consciousness and of mind in general. The little knots with irregular radiating fibers proceeding from them in various directions are the corpuscles of the brain, or brain cells, which are scattered, not wholly without order, through the general mass, from the surface of the convolutions above to the white matter below. The existence of these cells has long been known, but the nature of the thread-like processes which go out from them has only recently been discovered. Not being an anatomist myself, and yet wishing to be altogether correct on such an important point, I shall in what I say relative to these facts chiefly quote, with the permission of Dr. Baker, from an able but as yet unpublished memoir of his, which he has done me the favor to place in my hands.†

"It has long been known that a considerable portion of the cortex is occupied by large cells of a triangular outline, presenting a pointed extremity towards the exterior. These, the pyramidal cells of authors, are of great size in the so-called motor regions of the cortex—that is to say, in the central convolutions. - - - These structures have wide-reaching connections; and Ramón y Cajal, and Van Gehuchten, have much extended our knowledge. - - - It has been noted that there appears to be a direct proportion between the size of a nerve cell and the number and length of its processes. This is justified in the present instance, for there extend from these cells highly complicated processes, some of them of great length. From the apex of the cell a protoplasmic stem passes up through the superficial layers of the cortex and

* This chart was one prepared by Dr. Frank Baker to illustrate his anatomical lectures. It is an enlargement of one of the excellent figures of Ramón y Cajal in a paper entitled "Sur la Structure de l'Ecorce Cérébrale de quelques Mammifères," published in *La Cellule*, vol. VII, pp. 123–176, 3 plates, pl. ii, fig. 7.

Since this lecture was delivered Dr. Baker has published in the *New York Medical Journal* for June 17 and 24, 1893, an exhaustive review of "Recent discoveries in the nervous system," in which he has reproduced many of the most important figures bearing on the subject. Fig. 15 of that paper is the one referred to, and is here borrowed from it. (*New York Medical Journal*, vol. LVII, June 24, 1893, p. 685.)

† Since published as above stated. The passages quoted occur on page 685 of the *New York Medical Journal* for June 24, 1893, in connection with the accompanying figure.

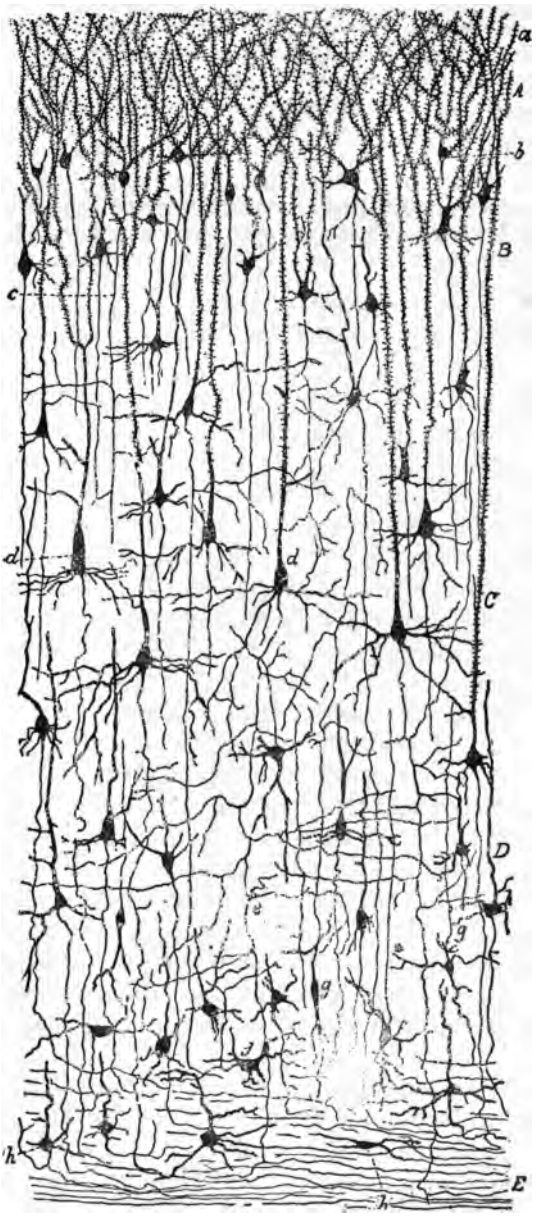

FIG. 1.—Section of the cerebral cortex (Ramón y Cajal). From the supraventricular region of a ung mouse. A. Molecular layers. B. Small pyramidal layers. C. Large pyramidal layer. D. Layer irregular corpuscles. E. White matter. *a*, panicles of the pyramids; *b*, smallest and most super- ial of the pyramids; *c*, axis cylinder from a small pyramid; *d*, large pyramid; *e*, its axis cylinder; cell with ascending axis cylinder; *g*, similar but smaller cells; *h*, cells found in the white matter; rounded cell that sends its axis cylinder toward the white substance; *j*. cell with short axis cylinder ocess.

terminates in an arched arborescent panicle, each composed of plume like expansions barbed with secondary spines. These panicles interlace with each other throughout the superficial layer of the cortex in the most intricate manner, forming a perfect forest of branches which, however, never anastomose with each other. - - - Besides the extraordinary appearance and peculiar situation of these cells there are reasons drawn from embryology and from comparative anatomy that indicate the probability that they are the chief agents in the psychic activity of the cortex. As we ascend the scale from the lower vertebrates to man an increasing complexity of structure is found in these cells, and there is also seen a similar progressive development when the different stages of their growth in the embryo are observed. Ramón y Cajal has therefore given to these structures the name of *psychic* cells."*

As Dr. Baker indicates, the Spanish investigator lays it down as a general principle that the farther back we go in the ontogeny of the brain of mammals, that is, the younger the specimen is that is being studied, the fewer and shorter become the protoplasmic expansions, and that the same is true of their phylogeny, that is, as we descend in the scale of organization. It is probable that the failure to discover these important facts before is largely due to the circumstance that early investigations were chiefly confined to the brain of man, or of the most highly developed animals, and at adult stages, in which the processes were much too long to be either successfully traced to their ultimate terminations or brought within the field of the microscope. And I may say that this chart represents a portion of the cerebrum of a mouse at the age of one month. If it requires such a complicated brain structure to conduct the simple psychic activities of so humble a creature, what must be the structure required to conduct the psychic activities of a Newton or a Herbert Spencer?

"As a final synthesis," says Ramón y Cajal, "it may be affirmed that the human brain owes in great part the superiority of its activity, not only to the considerable number of its elements, but especially to the extraordinary richness of its means of association, that is, to the collateral branches of the axis cylinders, the protoplasmic ramifications, etc."

It will thus be perceived that in all this we are dealing altogether and essentially with protoplasm and the mechanical means of enabling it to do the maximum work. Brain cells, cellular trunks, lateral branches, plumose denticulations, axis cylinders, all consist chiefly or wholly of protoplasm.

Just as the essential thing in life is spontaneous movement, or motility, so the essential thing in mind is conscious sensibility, or awareness.

* "Tal es la disposición de la célula piramidal de los mamiferos, de la que podríamos llamar, invocando su especial morfología y su exclusivo yacimiento en la corteza cerebral, *substractum* de las mas elevadas actividades nerviosas, *célula psiquica*." Ramón y Cajal: Nuevo Concepto de la Histología de los Centros Nerviosos. Revista de Ciencias Médicas de Barcelona (reprint from vol. XVIII, Barcelona, 1893, p. 27).

Upon these as foundations the body and mind, respectively, of all living things, including man, have been built up by the organizing powers of nature. We are now only concerned with the latter, and the object in tracing these initial steps has been to show as clearly as possible wherein the great "mystery of mind" lies, about which, as shown by the passages I have quoted, the scientific world seems to be so greatly exercised. It was proposed to inquire as to the necessity for laying so great stress upon the admitted fact that we do not and perhaps never shall understand the relation that subsists between mind and body, between psychosis and neurosis, between states of brain and states of consciousness. If the progress of development has been anything analogous to what I have outlined, if mind is a property of organized protoplasm, or if any such relation subsists between mind and body as subsists between substances and their properties, then the question at once arises whether the great "mystery" has been located at the right place, and whether it would not be much more logical to locate it farther down in the scale of development, and not confine it to this one highest stage. For we are obliged to confess, with the same abject humility as we confess our ignorance of mind, that the simplest properties of the humblest forms of matter are utterly inexplicable. We know just as much about why nerves feel and brain thinks as we do about why sugar is sweet or lead heavy. Even the simplest of all physical phenomena, those of gravitation, are utterly unknown to man except as observed facts and formulated laws. He is still as ignorant of why an apple falls to the ground as he is of why he can remember that he saw it do so. Prof. James, in commenting upon Prof. Ladd's views respecting memory, says, after quoting a passage from the well-known work of the latter:

"This passage seems to me characteristic of the reigning half-way modes of thought. It puts the difficulties in the wrong places. - - - The result is various confused and scattered mysteries and unsatisfied intellectual desires. But why not 'pool' our mysteries into one great mystery, the mystery that brain-processes occasion knowledge at all?"*

I would go much further than Prof. James, and say that not only Prof. Ladd but himself as well, and nearly all those who have expressed themselves on the subject, "put the difficulties in the wrong places." And I would also go much further than he in the direction of "pooling" the mysteries. The great mystery is not merely "that brain-processes occasion knowledge," or that nerve vibrations occasion feeling, but that molecular activities should occasion any of the properties that bodies present. It is not mind alone, but matter also and equally, whose ways are beyond our powers. We can paraphrase every one of the sayings of the great men that I have quoted. Alongside of Tyndall's remark that "the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable," we can put the parallel truth that the

*Principles of Psychology, vol. i, pp. 688, 689.

passage from the constitution of matter to the corresponding properties of matter is unthinkable. When Spencer asks, "Can the oscillation of a molecule be represented in consciousness side by side with a nervous shock and the two be recognized as one?" we may with equal propriety ask: Can the oscillation of an atom be represented in consciousness side by side with a magnetic attraction and the two be recognized as one? Prof. LeConte's brilliant comparison of psychic phenomena to the genii that spring forth when the lamp of Aladdin is rubbed is equally applicable to any kind of physical phenomena. And I fail to see why Prof. James's epigram, "motion became a feeling" is any more absurd than it is to say, "a motion became a color." Yet modern science teaches that light, which embraces all color, is "a mode of motion."

But are we, after all, so profoundly ignorant of the underlying principles of nature as all this would imply? Do we, then, know nothing of forces, and properties, and causes?

There is, it is true, a school of philosophers, the positivists, who insist that all investigation into the causes of things is wasted labor, and that science progresses solely through the study of phenomena and their laws. Comte, the founder of this school, taught that all we know or can ever hope to know is the relations that events sustain to one another; that what we call cause and effect is simply succession. There is much truth in this, but the stress which positivists lay upon the laws of phenomena contains within itself an admission of all that anyone need claim, the admission, namely, that the succession of which they speak is an orderly succession, that sequences follow antecedents in a uniform and invariable manner, so uniform and invariable that they can be depended upon absolutely; otherwise it would be impossible to arrive at any laws, and there would be no such thing as science. But this is what is meant by cause and effect. When this regular and orderly sequence is known the causes are known, i. e., the proximate causes, and all causes, however far we may trace them back, are necessarily proximate, for every cause is itself the effect of an antecedent cause, and every effect is the cause of a subsequent effect. So long, then, as the succession is perfectly invariable it is, to all intents and purposes, a succession of cause and effect, and no one claims that the series can be traced to its origin or its termination; for every series is infinite. And this is all there is of the mystery, and the ostentatious confession that scientific men make is nothing more than the confession that they are finite beings.

But the forces of nature *are* uniform and reliable. The properties of matter *are* always the same for the same substance. Bodies manifesting the same properties must be of the same internal constitution—must be the same substance. "Show me," said Bacon, "a substance that hath all the properties of gold, and let fools contend whether it be

gold or no." Not less is this true of the brain and nervous system in their relations to thought and feeling. The laws of mind are as uniform and invariable as the laws of matter. They are the laws of matter in its most highly developed form. The relation of brain-states to states of consciousness are not accidental and haphazard relations. They are rigidly fixed and invariable relations. The former are therefore the uniform antecedents and true proximate causes of the latter, and so far as we know these relations we really know the cause of mind.

I have endeavored to show that the prevailing fashion among scientific men of emphasizing the so-called "mystery of mind" is unnecessary and illogical, since mind is no more a mystery than matter, and that all that there is any ground for confessing is that, in consequence of the greater complexity of mental phenomena, due to the higher state of development of the material basis of mind, we possess as yet much less knowledge of them than we do of many of the simpler phenomena of nature. This habit can be nothing better than a relic of the old preconception in favor of the essential dignity of mind which went along with the notion of the essential unworthiness of matter—a preconception grounded in hypocrisy, in that it sought to cloak under a show of humility the egotistical pretension to divine attributes. It is therefore altogether unworthy of those who profess to be in search of truth solely for truth's sake.

I promised that I would also consider the desirability or advisability of assuming this attitude, considered independently, so far as this was possible, of its logical tenability. Of course, if the position is not a sound one this also at once condemns it from the point of view of advisability; but waiving that point, let us consider for a moment a few of the consequences to which it naturally leads. It is a well-known characteristic of the human mind to love the marvellous, to feast on the magical and occult, to hug delusions, to prefer the improbable and mysterious, and not merely to believe the impossible, but to believe it because it is impossible. The motto of science is *nil admirari* (wonder at nothing). And in the face of this known quality of the human mind it behooves men of science to guard themselves firmly against feeding this popular appetite for magic and superstition. But the moment the possibility is conceded that mind or any part of mind can have an existence separate from and independent of body, the door is opened for the crudest theories, the wildest speculations, and the most unbridled fantasies. Encouraged by such utterances as I have quoted from men of science, there has already come forward into prominence what claims to be a "science" founded on the essential autonomy of mind, and the wonder-loving public is rallying to it as though the salvation of the race depended upon it. We hear much of "thought transference" or "telepathy," and the claim is openly made that "the action of one mind upon another independently of the recognized channels of

sense" has been experimentally established. Far more astonishing things than this, indeed, as you all know, are now boldly claimed in the name of science. They are all based on the assumption that the mind, or something that must be embraced under any proper definition of mind, since it is no part of the body, is capable of cutting loose from its corporeal belongings and proceeding through space, exerting force upon material objects and taking possession of other bodies. Those who claim to be "investigating" such alleged facts, or at least most of them, proceed upon a principle the exact reverse of that by which all experimental science advances. Instead of making truth the end, and employing hypothesis as an instrument for guiding them to the truth, they make their hypothesis the end, and conduct their experiments with a view to finding some support, however slender, for their hypothesis. I need not tell you that nothing that the scientific world will accept as proof that any of these phenomena take place has ever been brought forward, and my only purpose in referring to the subject is to show the utter chaos into which the admission of the possibility of such things would plunge the whole science of mind.

The phenomena of mind must be investigated according to the same principles and by the same methods as other classes of phenomena; and this is what is actually being done by the modern school of experimental psychologists. And even at this early stage we are beginning to see what is likely to prove the basis of all the error that prevails and has always prevailed respecting the mind. Fundamentally, of course, it is due to ignorance of what the mind is, chiefly to the false belief in its independence of the body, but more particularly it rests upon the failure until recently to discover the true nature of consciousness, i. e., of the central or controlling principle of mind, that which makes every individual distinctively himself and no one else. In the great majority of cases this supreme authority is something fixed for each individual and permanently connected with his individuality during the whole of his life. But it is now beginning to be seen that this is far from being universally true, and the cases of "double consciousness" that have been dwelt upon so much of late, bewildering as they are to the unphilosophical, have furnished the key to the solution of the greater part of the mysteries that have beset the study of mind. It is now seen that hypnotism belongs to the same class, and that self-hypnotism, or so-called mediumship, when it is genuine, is simply a case of temporary double consciousness. And between this and the familiar fact of "unconscious cerebration" all the intervening steps can be traced. The influence of "expectancy" and the laws governing hallucinations are also becoming understood, and we seem to be in the way of ultimately explaining on scientific principles most of the psychic phenomena that have so long seemed miraculous.

Some there are, I presume, who will look upon the scientific explanation of mind which I have endeavored to bring forward as *materialistic*. If to posit a material basis for the phenomena of mind be materialism it were useless to attempt to evade the charge. But in these days of the apotheosis of matter this charge is without force for those who possess any considerable acquaintance with the material world. If however the term materialism be employed in its only proper and legitimate sense as postulating the material nature of mind itself, the scientific conception of mind is the farthest remove possible from a materialistic conception. The antithesis between matter and property is absolute. Mere attributes are in the clearest sense of the word *immaterial*, and mind is simply an attribute. From this point of view it would be as reasonable to say that love, or honesty, or justice, or liberty were material things as to say that feeling and thought are such.

If, on the other hand, we glance at the theory of mind that stands opposed to the scientific view it is difficult to see how the charge of materialism can be escaped. If there is an element—call it mind, thought, soul, spirit, or what not—that can detach itself from the personality to whom it normally belongs, and pass into another body, or remain in space performing mechanical operations upon material objects, it matters not whether it be visible or invisible, or whether it can appeal in any way directly to sense or not, such a thing possesses the nature of a material body, as much so as the invisible atmosphere, the rarer gases, or the vastly more tenuous æther that vibrates to so great purpose against the retina of the eye. Turn it as you will, twist it as you may, matter can only be affected by matter, and the impact of moving matter against other matter is, in the last analysis, the essence of force. And this is true of the method which mind itself employs. Thought and feeling in and of themselves are powerless. They can only act through a motor system which uniformly and necessarily accompanies the sensor system, which transfers molecular nerve vibrations to the muscles, transforms them into molar motions, and communicates them mechanically to the world without. It is this that we mean by the term *expression*, whether it be of emotions or of ideas. It is thus that you are able to sit where you are and learn what my thoughts are. If I were merely to stand here and think my thoughts the nearest of you would gain no intimation of the nature of those thoughts.

This view of mind has all the promise of a true science. Mind is a great power in the world. It has wrought mighty changes in the past and is destined to work still mightier ones in the future. And an experimental psychology is destined to place the laws of mind within the grasp of man, even as experimental physics and chemistry have placed the laws of matter within his power. The opposite view, which no one will complain if I characterize as ontological, and which I have

shown to be essentially materialistic, merely represents the alchemy of mind. The so-called "psychical researchers" are simply searching for the philosopher's stone. The same class have always been seeking it, and until late in the present century the whole domain of mind was in its pre-Baconian and medieval stage. The baser metals of mind will be transformed into gold by the new science of psychology in the same way that those of matter were transformed by chemistry, and if the race of psychic alchemists who think that gold alone has value are disappointed, the rest of the world will rejoice, as it always rejoices when science triumphs over magic.

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THE EARTH THE HOME OF MAN.*

By W J McGEE.

MAN'S PLACE IN NATURE.

Life in the Cosmos.—The earth is the home of living things. The waters of the earth abound in lowly forms of life, beginning with simple beings of indefinite structure made up of undifferentiated protoplasm, running through a long series of successively higher forms, and ending with the vertebrates, of which some belong to the mammalia, and thus approach the highest known life-forms; the air is inhabited by winged insects and flying birds with a few flying beasts, and all of these bees and beetles, birds and bats, are highly organized, while many of the lands of the earth teem with plant and animal life, ranging from the simplest to the most complex in degree of development, in perfection of organization. In addition, the plant-bearing soils of the earth comprise a mixture of plant remains and mineral substances decomposed and recomposed by plant action; and furthermore, most of the rock formations of which the land is made up were originally sediments of the sea bottom and are composed in part of the remains of organisms of past ages and in still greater part of complex chemic compounds due to vital action during the eons of world growth; and these fruits of earlier life stored up in soils and rocks are the germs and nursery of later life. So the air, water, and land abound in living things and the whole earth teems with life and pulsates with vitality.

Living things are distinguished from non-living matter commonly by organization or by an arrangement of parts in definite relation to the whole (e. g., the roots, stem, leaves, flowers, and fruit of a plant, or the heart, lungs, stomach, and brain of an animal), always by a distinctive manifestation of force commonly spoken of as vitality or vital force. Now vital force is manifested by certain highly complex chemic compounds, and is not manifested by matter in other and simpler forms; indeed the more complex, at least, among the higher compounds appear to

*A Saturday lecture delivered in the lecture hall of the U. S. National Museum, under the auspices of the Anthropological Society of Washington.

depend for their very existence on the distinctive force which they manifest, since they are decomposed into simpler compounds when vitality is destroyed. Again the potency of vital force as manifested among the higher compounds appears to vary, within certain limits, directly with their complexity; thus, in general, the tissues of living and moving animals are more complex chemically than the tissues of plants which live and do not move; the flowers and fruits in which the vitality of plant species resides are more complex in constitution than the woody stems and other structures of simpler function; the germ in a grain of wheat or corn is more complex chemically than the surrounding envelope from which the budding plant derives nutriment; and the animal brain, which not only lives and moves, but displays a wider range of activities and susceptibilities than any other known substance, is made up of the most highly complex compounds known to chemistry. So chemic constitution and vitality appear to be inter-dependent and at least in some degree correlative, and the living things of the earth live, move, perceive, and act according to the constitution of the earth-stuff of which their substance is made.

Like all other chemically complex substances, the compounds of carbon, hydrogen, oxygen, nitrogen, etc., which manifest vital force are highly susceptible to chemic action and reaction, and even to molecular and molar movements; *i. e.*, they are highly unstable. It is, indeed, this ready susceptibility to external forces and conditions that raises living matter above the plane of the inorganic. Moreover, the higher compounds are more unstable than the lower to the extent that they can exist only under delicately balanced chemic conditions, themselves depending on narrowly limited molecular conditions; thus, wood and ivory are decomposed by certain acids or by heat; the soft tissues of plants are broken down by more dilute acids or lower heat; the tissues of the higher animals break down under still weaker acid or still lower heat; and nerve matter is disorganized by a multitude of poisons, by changes of temperature running through only a few degrees, even by slight mechanical shock. Indeed, so delicate is the adjustment between living matter and the conditions by which it is environed that if the mean temperature of the earth were raised or lowered through only a few dozen degrees, the teeming life of air, water, and land would cease to exist; and if the heating or cooling extended through a few score, or, at the most, a few hundred degrees, every compound known to manifest vitality would be destroyed. This delicacy of adjustment between life and its environment is constantly to be remembered in considering the origin and history of living things. Astronomy and geology teach that the earth is a cooling body, and that it is only during the last stage in world growth—the stage covered or nearly covered by geologic history—that the temperature has been so far reduced as to permit living things, or even the unstable compounds of which they are composed, to exist on the earth. So,

while the unwritten history of the earth, running from primeval chaos to the age of man, is long and writ in many chapters, it is only in the last chapter that the record of life appears.

The dependence of life on chemic conditions and on temperature and other molecular conditions must limit its distribution in the cosmos. Thus, it is evident that living things such as those of our planet can not exist on the sun or other stellar bodies, for they are so hot as to decompose the unstable carbon-hydrogen-nitrogen compounds which alone manifest vital energy; nor can organisms like unto those of our earth inhabit the moon, for its temperature is so low that the vital fluids would be congealed; nor can life as we know it exist on the planet Jupiter, since he is almost certainly too hot, on the planet Mercury, since the daily temperature changes are almost certainly too great, or with any degree of probability on any other planet save possibly Mars, which may, perchance, be neither too hot nor too cold nor subject to so great temperature changes as to break up the unstable compounds of which living things are made. There may be other planets revolving about other suns so conditioned as to support life analogous to that of our earth, but if so, they are beyond the reach of the telescope, outside the ken of science; and it is of course possible, though not clearly conceivable to trained thought, that life may be manifested on other cosmic bodies by chemic compounds differing from, and under molecular conditions unlike unto those of our planet, just as it is possible, though not easily conceivable, that molten lead may be an agreeable beverage in some other part of the cosmos; but with such possibilities exact knowledge has nothing to do.

The exceeding susceptibility of living things to external forces and conditions gives meaning to the terms "vital force" and "vitality," which would seem to be nothing more than convenient and non-committal expressions for this susceptibility and its attendant reactions, and indeed Spencer has defined life as "The continuous adjustment of internal relations to external relations;" but since all known manifestations of vitality are conditioned on chemic constitution, which is in turn limited by temperature and other molecular conditions themselves depending on cosmic relation, it is evident that this definition is hardly so exact and so comprehensive as present knowledge requires; and life has been defined elsewhere as "'The continuous adjustment of internal relations to external relations' among certain definite chemic compounds under certain molecular conditions determined by exceptional cosmic relations." Now, while this definition is not an explanation of the nature and development of living things, it suggests an hypothesis of life which may be enunciated as follows: (1) The known chemic compounds are more or less *unstable*, and in general their instability varies directly with their complexity. (2) The higher compounds are so unstable as to be incapable of existing save under an exceedingly narrow range of chemic and physical conditions; they are, therefore, in a

high degree *susceptible* to external forces and conditions. (3) The highly unstable compounds are sometimes unaffected, sometimes modified, sometimes destroyed by external forces and conditions; when those that are unaffected retain their primitive character and are thereby excluded from the category of the susceptible, and those that are destroyed disappear from the scene of cosmic activity in their original form, while those that are modified are thereby more delicately adjusted to the sum of external forces and conditions. (4) Through the exclusion of the insusceptible, destruction of the over-sensitive, and preservation of the delicately adjusted among the higher chemic compounds, resilience—or the capacity for internal reaction, or response to external forces and conditions may be developed gradually through that continuous transition which characterizes natural processes and which Powell has formulated as "The Law of Becoming." (5) The responsive compounds are constantly coming into contact or collision with the external; when those that are not affected by the collisions retain their character and are thereby excluded from further progress, and those that are excessively affected are destroyed, while those that yield to or interact with the external are preserved and thereby brought into closer harmony with a wider range of cosmic forces and conditions; and this adjustment to the widest possible range of forces and conditions makes for the preservation of the compounds thus constituted. (6) Through the exclusion of the irresponsive, destruction of the over-responsive, and preservation of the duly responsive among the delicately adjusted higher chemic compounds, internal activity may be developed to such a degree that each contact with the external may initiate a long-continued series of internal movements, *i. e.*, a limited spontaneity may be developed. (7) While spontaneity might not directly tend to increase the probability of survival among—and thus might not prove directly beneficial to—highly unstable compounds, it would nevertheless accompany that delicacy of adjustment required for its survival (*e. g.*, perhaps, as functionless tactile sense accompanies the distinct special senses of the delicately constituted tongue and eye); and thus the endless succession of collisions characteristic of the cosmos would tend to exclude the non-spontaneous, eliminate the over-spontaneous, and preserve the duly spontaneous, and so make for the increase in spontaneity. (8) Despite their wide variety there is a certain rhythm in cosmic movements (*e. g.*, growing out of rotation and revolution in relation to other bodies) which imposes a certain degree of order on cosmic collisions; and those spontaneous compounds whose internal activities chance to accord with the external rhythm enjoy the greater probability of survival, and thus rhythmic inter-action between the internal and the external may be developed. (9) Through the exclusion of the non-rhythmic, elimination of the ill-rhythmic, and preservation of the duly rhythmic among the spontaneous compounds, attunement to the external, or rhythmic spontaneity,

may gradually be developed through the continuous transition comprehended under the law of becoming. (10) That internal adjustment to subsequent external events, which attunement between the internal and the external involves, is directly beneficial to compounds possessing such constitution; and, as the attunement becomes more perfect and extends to successively wider ranges of external forces and conditions, the internal activities may eventually become such as are determined by past experiences, so that the faculty of prevision may be engendered; and prevision, or the prediction of the future in terms of the past, is the beginning and essence of consciousness.

It is to be noted that the unstable, susceptible, and responsive compounds and those manifesting both simple spontaneity and rhythmic spontaneity are modified—sometimes by few, sometimes by many, external forces and conditions; when those that are affected by few causes change slowly and retain long their primitive character, and are thereby excluded from the leading rank in adjustment to the sum of the external, while those that are affected by many causes are thereby brought into correspondence, or harmony, or accord, or congruity with the wider range of cosmic forces and conditions. Now, through the exclusion of the less congruous and the preservation of the more congruous, exceptionally responsive, and widely congruous, materials may be developed through a series of successive inter-actions between the substance and the environing forces and conditions, when the condition recognized in Spencer's definition of life will be fulfilled. Moreover, through the exclusion of those materials whose external activities represent immediate causes and the preservation of those whose internal activities represent remote causes, spontaneity, both simple and rhythmic, may be developed to such an extent as to be limited only by the persistence or durability of the material.

Thus, under this hypothesis of life, vitality includes susceptibility to external forces and conditions analogous to, if not identical with, that of the higher abitotic chemic compounds, together with responsion, through which the substances by which it is manifested are themselves modified, as well as a high degree of spontaneity, whereby long continued internal activity is secured and, sometimes, rhythmic inter-action between the internal and the external or prevision, which is the basis of consciousness, and also congruity with the forces and conditions of the cosmos. Accordingly, life may be defined as *the limitedly spontaneous inter-adjustment of internal and external relations between congruous substance and its environment;* or, more briefly, as *the spontaneous inter-adjustment of the congruous.*

In this hypothesis of vitality, it is assumed that the primary activities are simply those growing out of chemic action and physical inter-action; and it is assumed that the material or materials vitalized through long continued series of inter-adjustments are at the outset produced continuously by combination of contiguous lower compounds and ele-

ments, and this may have been the beginning of absorption or material growth, after a manner analogous to that of the growth of crystals. Thereby a vitalized self-perpetuating magma may have been produced wherever the chemic and physical conditions were favorable. Now it would appear that an essential antecedent condition for the production of such vitalized substances as those found in the waters and over the lands of the earth would be the presence of carbon, oxygen, nitrogen, hydrogen, and certain other elementary substances either free or in easily modified combinations. Several of these elements of the vital compounds are known to exist free or in readily combined or dissociated compounds at the present time; but it is singular that hydrogen is rarely found free in the modern earth, and indeed could hardly now exist on the terrestrial surface, since its specific gravity is so low that it would quickly be displaced by denser gases. This fact suggests that vitalized materials could not originate spontaneously under the existing cosmic conditions by which the earth is environed; and, while it is difficult to understand how this highly elastic gas was chained to the earth in its earlier stages, it seems on the whole probable that the life of the earth began, and could only have begun, about the period of transition from the planetary stage to the stage of geologic development. Accordingly it would appear probable that the course of life on the earth has run parallel with the differentiation of the terrestrial surface into oceans and continents, sea and land, mountain, valley, and plain.

While the above hypothesis explains the development of spontaneous inter-action, or of motility, in a vitalized magma, it does not directly explain the origin of reproduction nor the development of individuals and organization; but it readily suggests the supplementary explanation. The vitalized magma, whose persistence depended on adjustment to external forces and conditions, was constrained by gravity and thus limited in size; large masses were liable to break beneath their own weight and even the smaller were liable to disruption by impact against other masses. Now, those that were reduced to simpler chemic form in consequence of disruption were thereby destroyed and removed from the race for survival, while those that resisted decomposition were thereby the more delicately adjusted to their environment, and through this process of the destruction of the indivisible, and the preservation of the divisible, the capacity for division was developed; and such may have been the beginning of multiplication by fission, the simplest form of reproduction, to which all others may be traced. At first the chances of survival of the two parts of a body divided by fission may have been equal, and, judging from the analogy of the vast numbers of lower organisms destroyed through the struggle for existence, myriads of primitive bodies must have been divided and eventually destroyed in the endless succession of mechanical shocks characteristic of cosmic existence before a higher mode of reproduction was

developed; but whenever a body was of such size and such chemic constitution that when divided one of its parts chanced to be more delicately adjusted to environment than the other part, then (1) the more delicately adjusted part survived the longer, and (2) the parent body which divided unequally thereby secured an increased chance of perpetuating a part of its substance; and thus, by the destruction of bodies dividing equally and the preservation of the more highly developed portions of those dividing unequally, unequal division may have been developed, and the plane of vitality raised by the elimination of the lower and the conservation of the higher in individual bodies, and this may have been the beginning of reproduction by budding or by the formation of spores and the germ of organization. Accordingly the inter-adjustments growing out of chemic and mechanical action may be traced with unbroken continuity through the beginning of absorption or growth, the primitive stages of individuation, the simpler forms of reproduction, and the inception of organization, *i. e.*, to those characteristic vital processes common to the living things of the earth.

Thus the hypothesis explains the origin and development of those attributes of living things which are commonly regarded as primitive or fundamental, and moreover it explains the still more important though frequently neglected quality of heredity among the simplest forms of life. Under the hypothesis, heredity, or the persistence of primary characters, is in no way dependent on cell structure or any other feature of organization, but on chemic composition, and varies directly with the stability of the chemic compounds of which the bodies are composed and inversely with the susceptibility of the compounds to external forces and conditions, *i. e.*, to vitality. So it would appear that, in so far at least as bodily constitution is concerned, heredity is a primitive character, and that the degree of vitality, or the potency of life, culminates in the highest organisms; though the persistence of vitality, or the resistance of a body to dissolution, culminates among the simplest and lowest living things. This inference is in accord with the sum of knowledge concerning the organisms of the earth. The lowly slime-molds, which in one stage of their existence are undifferentiated protoplasm, maintain their specific purity more rigidly than any of the higher life forms, for, although the protoplasm-streams from the spores of two species may intermingle, each reproduces its kind with the highest exactitude; the Palæozoic brachiopods and corals lived through geologic ages, each made up of uncounted millenniums, without appreciable change in specific character, and each individual was the exact image of his fellows; in the later geologic ages the persistence of the species progressively diminished, and the diversity among individuals of the same species progressively increased; the prevailing species of to-day are constantly adjusting themselves to general environment, and the individuals of each species are constantly adjusting

themselves to local environment, so that this may justly be called the age of specific and individual variation, or the age of hybrids; indeed, in this last eon of the history of the earth heredity is so far subordinated to responsion and spontaneity that many animals and plants are no longer able unaided to perpetuate their kind, while the domesticated animals and cultivated plants have lost their original affinities and become the creatures of human craft. Accordingly life—which represents the highest susceptibility to external forces and conditions, the attunement of the creature to the harmony of the cosmos—buds in the zoöphyte, blooms brightly in the busy ant, the bounding antelope, and the soaring eagle, and burgeons gloriously in the active brain of man; and the potency and perfection of life, the value of vitality, increases progressively from the lowest to the highest among the living things of the earth.

In brief, life is a manifestation of force pertaining to certain highly complex and unstable compounds which have abounded on the earth during the ages recorded in geologic history, but which can not have existed during the earlier stages of planetary growth and can not exist to-day—except in a relatively minute part of the known cosmos; out of all the innumerable self-luminous suns that jewel the firmament, out of the seven great planets and the hundreds of asteroids that wheel about our sun, out of the score of satellites circling the planets of our solar system, out of all the myriad cosmic bodies within range of human vision, there is but one which is certainly so conditioned, and one or two more possibly so conditioned, as to permit the existence of vital compounds on their surfaces. Accordingly, the earth is not only the home of living things, but, so far as human knowledge extends, their only home.

The development of life.—The development of living things from the simple and lowly forms of the prime to the highly organized animals of the present is recorded in fossils and other organic remains in the rocks of the earth; and indeed, the rocks are classified by the records of past life entombed within them. In the present age of the earth, intelligent man prevails and events are recorded in written history; but the written record covers no more than a few thousand years, even in the oldest nations. Next beyond the historic age lies a shadowy and ill-defined pre-historic age, during which primitive man probably existed, and then follows the Cenozoic age of the geologist, the age of modern life, in which living creatures approached more or less closely to the modern forms, the animals being known from their bones, teeth, shells, and tracks, and the plants from their wood, leaves, and fruits preserved as fossils in the newer rock formations. Beyond the Cenozoic age falls the Mesozoic age, or age of middle life, whose rocks underlying the Cenozoic yield fossil remains of plants and animals simpler, cruder, more primitive than those of modern times; still further away from the present are the records of the Palæozoic age, or age of early life, in

which the living things were like unto the simplest and lowliest of the present, or even simpler or lowlier than any now existing, as shown by the fossils from the older rocks; while the earliest age with which the science of past life has to deal—the Agnotozoic age, or age of unknown life-forms—yields but a meager and indefinite record of the beginning of organic existence.

Now, while the history of the development of life on the planet is too long and too elaborate for repetition here and while it is obscure in many portions, certain tendencies or laws are indicated within it which are worthy of special attention: At first the living things were apparently devoid of woody, stony, and bony structures, like the lowest plants and animals of later ages, and were probably akin to the monera and related creatures of the present, simple, ill-organized masses of protoplasm gradually assuming cell structure and an indefinite organization; their bodies probably consisted of relatively simple compounds of carbon, hydrogen, nitrogen, etc., as do the bodies of the amœbæ to-day; their vital characteristics were probably limited to simple motility, irritability, metabolism, and heredity, as is the case with the simplest forms of life known to modern students; and it is probable that by far the most important of these characteristics was that which is frequently neglected in the consideration of early life, namely, heredity; and the beings themselves, like the relatively simple compounds of which they consisted, were probably far more stable, both individually and specifically, than their more highly organized progeny—so stable, indeed, that some of their kind have come down to the present with little modification. Such, doubtless, was the beginning of life on the earth, and the condition of life during at least a part of the Agnotozoic, though it is probable that higher life forms came into being before the end of the Agnotozoic and that their remains will some day be found in the form of fossils.

During the Palæozoic age—the age of early life—the living things differentiated into plants and animals, chiefly marine; for in that stage of world-growth the oceans were greater and the lands were smaller than to-day: The plants at first were simple seaweeds, but later they crept out of the waters on the growing land surfaces as forests of huge ferns, giant mosses, tree-like rushes, and other plant types similar to certain pigmy forms of to-day, though hundreds or thousands of times larger; the animals were at first mollusks, corals, crab-like trilobites, plant-like crinoids—the stone lilies of the primitive period—and sea-worms with stony or chitinous structures for shells and skeletons; but, later, vertebrates were developed and they and some other organisms pushed out on the land amidst the forests of ferns and mosses. During this age the organization of animals and plants increased greatly in complexity; at the same time the chemic compounds of which they were composed increased in complexity and the organisms diminished in stability, so that few of the plants and animals of that early day have come down to us in unchanged condition.

During the Mesozoic age, or age of middle life, the marine animals and plants differentiated and became more complex and unstable; but life came to prevail over the land and the dominant types breathed air rather than water. The four-footed beasts increased in number and in strength; flying insects began to buzz among the trees, and birds harbored in the forests; and the beetles fertilized those plants that began to bear flowers, and the birds distributed the seeds of those that began to bear fruits; and thus the plant life of the land was changed. During this age the organization of living things was still further perfected, and progressively more and more complex chemic compounds were probably produced by vital action; at the same time the stability of animals and vegetal forms diminished so that few of the Mesozoic types have come down to us, and the Mesozoic fossils are less useful for classification than those of the earlier ages by reason of their variability.

During the Cenozoic, life continued to prevail on the land, and insects, birds, and beasts became more and more differentiated; talons and beaks grew among the birds of prey, and teeth, tusks, and claws among the beasts; while the plant-eaters grew fleet and cunning and there was a marvellous increase in the volume of the animal brain. Throughout this age bodily organization became more elaborate, while the chemic complexity, at least of brain matter, increased, and the stability of the higher forms continued to diminish.

During the historic period and the immediately antecedent pre-historic age made known to us through archæology, intelligence prevailed and man came to rule over the earth and to destroy or mold to his will the animals and plants; his brain is the most complex chemic compound known; and, while bodily variation in his kind seems to have ceased, his works and his institutions are constantly changing, ever for the better, so that this last short age is characterized by change more rapid than ever before in the history of the earth.

Thus the record of life on the earth runs from the ill-organized, chemically simple, and stable to the highly organized, chemically complex, and unstable among living things. The first age in the geologic history of the earth—the Agnotozoic—appears to have been one of simple, ill directed, unorganized, and feeble vital force, or of *vital magma;* the second, or Palæzoic, was the age of *numbers* when living things increased to multitudes of species and myriads of individuals; the Mesozoic, or middle life, was the age of *might* when brute strength prevailed and the theatre of vital action was changed from the sea to the land; the Cenozoic was the age of *activity* displayed first in fleetness and then in cunning, gradually growing into intelligence; while the present is the age of *mind*, in which organic development culminates in brain structure, while brain work controls the world.

So the history of past life on the earth pictures with marvellous clearness the relations among the living things of to-day, of which most are belated survivors from earlier ages and only a few with man at

their head, are really representative of the age of mind; the undirected or ill directed vital force of the beginning gave way to numbers of individuals, the numbers fell before individual might, brute force bowed before activity, and bodily activity has yielded to intelligence. The story of life on the earth is the grandest epic inscribed in the book of nature; and the record of man's place at the head of all other earthly things is its grandest canto.

The kindred of man.—In the beginning of biology, human knowledge was a chaos of isolated facts concerning living things whose relations were not perceived; in a later stage the living things were grouped in a hierarchy or orderly system of species, genera, families, and orders, which were recognized as running from the lowly and simple to the higher and more complex, and this arrangement was interpreted as the expression of a preternatural and admirable plan, and a long line of high priests of the gospel of special creation, ending with Agassiz and Dawson, extolled the wonderful works of the Creator. Then came Spencer, Darwin, and Wallace with the doctrine of evolution, and it was perceived that living things represent not simply a hierarchy running from the low to the high, but a genetic series, in which the higher sprang from the lower through the operation of natural forces and conditions implanted in the cosmos at the beginning, and thus residing in the earth; and thereby a new and nobler plan of creation was recognized, and the modern high priests extol a more exalted theme than the old.

Under the doctrine of evolution, the relations of the living things on the earth may be shown like the relations of individuals in a family group by a kind of genealogic tree whose numerous and widely diverging branches may be traced down to the primary stock. The stock of the tree of life on the earth stands for the simple life forms of the Agnotozoic when terrestrial vitality was represented by ill organized forces, and the stock divides upward with the development, multiplication, and differentiation of organisms; yet, like the trunk of the elm or oak, the original stem rises through the ages to the present and is represented by the existing amœboid forms and protoplasmic stages. One of the great branches springing from this trunk is represented by the animals of radiate structure, such as the crinoids and sea urchins, and this, like other great branches, is subdivided into many branchlets and twigs; another great branch is represented by the articulated animals with external chitinous or stony skeletons; and the most important branch, which is closely allied to that of articulates, is represented by animals with internal bony skeletons. The most important branchlet of this great branch is that of the mammalia; and most conspicuous among its twigs is that representing the animals with hands. Some there are indeed who question whether the mammalian branchlet of the vertebrate branch of the tree, or indeed any part thereof, supports the crowning glory of terrestrial vitality, the human organism; but the no-

tion that man is not a member of the earth's great family of living things has long been subsiding and must be finally set aside.

It is now a generation since Darwin showed that not only are the bones, muscles, nerves, and other organs of the lower animals essentially similar to those of man, but that there are found in the human body certain rudimentary organs—or vestigial organs, to use the more acceptable term proposed by Riley—which are without function and whose presence can be explained only on the hypothesis of descent from simian or pithecoid, (*i. e.*, ape-like or monkey-like) ancestors to whom these organs were of use; and about the same time Huxley showed that, when anatomical characters, particularly those of the brain and its receptacle, are compared, it is found that certain savages and idiots and other men of low development more closely resemble the higher apes than the higher representatives of the human species; in other words, that there is no anatomical break between man and the apes. Not long afterward Haeckel and others pointed out that the human embryo is undistinguishable from the embryos of the lower vertebrates and that in its gradual development into the human form it passes through successive stages of homology with reptilian, avian, and mammalian embryos, thus repeating in epitome the history of development previously inferred from anatomical characters; *i. e.*, the embryotic development of the human individual is inexplicable except on the hypothesis that man has come up from a lower estate and is thus the crowning glory of a long line of less noble ancestry. These demonstrations have sufficed to convince nearly all biologists that the human species (*Homo sapiens*) is genetically related to the anthropoid apes and through them to every part of the genetic series of terrestrial life. But each new discovery yields a higher point of view for further research into the undiscovered, and thus the progress of knowledge is cumulative; and recent researches in pyschology, based on the evolution of human characteristics, appear to yield new and absolutely conclusive proofs of man's ascent from a line of lower ancestry to his present condition.

As explained by Powell in his system of psychology and as specifically indicated in the foregoing hypothesis of vitality, mental action or mentation is the manifestation or product of inter-action between highly organized nerve substance and external forces. Now, the responsivity of nerve matter, which is the most highly complex and unstable among terrestrial compounds, would seem to be the outcome of a long course of development in which the irresponsive was destroyed and the highly responsive preserved; and, the final effect on the highly sensitive nerve matter of each collision between that matter and the external world being determined in large part by previous collisions, the character of each nerve reaction may be considered the resultant of all the inter-actions in the long course of physical development of which nerve matter is the fruit. Thus mentation would appear to be a link in the

chain of inter-adjustments constituting vitality, and that in which internal reaction or spontaneity is most perfectly developed.

Now, under this system of psychology, intellectual development must have been exceedingly slow; and while, like other natural processes, it must progress cumulatively with each new inter-action, as the structure of the nerve matter comes nearly and still more nearly into accord with its surroundings, still a vast period must have been required for the development of the higher grade of brain structure and the mentation characteristic of the age of intellect in the history of the earth. Moreover, the process of development must have been marked by certain stages coinciding with those actually displayed among the lower living things of the earth and displayed still more clearly among the lower living things of past geologic ages brought to our knowledge through palæontology. Thus, under Powell's system of psychology, which is by far the most satisfactory thus far formulated, the human brain is but the keystone of an arch rising through the lower organisms of earlier eons, the product of myriads of inter-actions and reactions covering the greater part of the period of life on the earth.

Under the Powellian psychology there is an embryology of the mind as well as of the body, and the mental development of the human infant is thus an epitome of the mental development not simply of the race, but of mankind, and even of the long series of lower and ever lower ancestors revealed as the scroll of world history is rolled backward.

Furthermore, under this system of psychology the intelligence of the world is essentially alike, differing perhaps in degree of development, but never in kind; always representing inter-action and revived action between highly organized nerve matter—chemically complex and unstable matter, which alone manifests, and which never exists without manifesting, this kind of activity—and external bodies or forms, whatever the degree of development of the organisms possessing it; and that which the hypothesis requires is found to be true among the living things of the earth. The intellect of man is similar in kind to that of domestic animals though higher in degree, and intelligence is conveyed to and received from the horse, the dog, the cow, and all other domestic animals; and when civilized man comes into contact with savage man or wild animals, the two grades of intellect are either mutually adjusted or the weaker is overcome. Moreover, the trend of intellectual action, the aim of intellectual organisms, is always alike: the intellect is the servant of the organism and seeks to protect and benefit its master through the conquest of natural forces and conditions. By reason of intellect, men build houses to protect themselves from enemies and the elements—so do birds, musk rats, and beavers; by reason of intellect, men hoard food—so do bees and squirrels; by reason of intellect, albeit hardly the highest, men enslave their kind—so do ants; by reason of intellect, men lay snares for game—so do spiders; by reason of in-

tellect, men plant and cultivate and afterward harvest—so, it is believed, do the ants of the southern plains; by reason of intellect, men band themselves together for mutual protection—so do birds and beasts on land and fishes in the sea; by reason of intellect, men arrogate unto themselves proprietary rights to certain land, and protect their domains against trespass—so, in somewhat less degree, do those carnivorous animals who establish and protect and mutually respect their ranges; and in many other ways the unity of mental action by men, lower mammals, cold-blooded vertebrates, and even the lowly articulates is displayed. It is indeed significant that the highest intellectual development among the living things of the globe seems to be reached in the widely diverging branches of the genealogic tree represented respectively by man among the vertebrates and the ant and the bee among the articulates, for thereby kinship among all living things is shown more clearly than by anatomic relations.

Thus the living things of the modern earth and all of their multifarious ancestry must be conceived to represent a single family bound together not simply by external resemblances and superficial affinities, but by blood relation. The way was long, very long, and very difficult from the beginning of responsivity in the highly complex compounds of the prime to the differentiation of even the lowest among the living things like the amœbas, and untold myriads on myriads of unorganized masses of differentiating matter fell by the wayside; the way was very long and hard from the simple mass of responsive matter capable only of perpetuating itself by absorption and reproducing its kind by fission to the development of simple organization, and myriads of the ill organized bodies fell out of the race; the way was long and devious from the beginning of definite organization to the development of individual might, when brute strength came to prevail, and the rocks of the earth are charged with the remains of the imperfectly organized beings that failed of this goal; the way was rugged from brute strength to activity and cunning whereby living things escaped their foes and fled the elements, and the wayside was strewn with the bodies of the ungainly and the stupid; the way was steep and dark from the activity of fleetness and cunning of the beasts to the comprehensive human intelligence that enslaves animal foes, imprisons fire, and chains the lightning, and in other ways molds the earth to his liking, and the weaker-minded were dazed or lost and left behind; but all these ways of progress join or overlap and through them all has man come to his resplendent castle on the crest of the delectable mountains.

The antiquity of man.—No definite record has yet been found of the beginning of human existence on the earth. Written history runs back into the haze of legend and ends in the shadow of myth at 5,000 or 6,000 years ago; but man was then a thinking, speaking, and writing man like the higher barbarians of to-day. Certain chronologic periods

based on astronomic observation indicate that the positions of the moon, sun, and stars, have been observed and recorded or remembered throughout a period extending over 10,000 or 20,000 years; but these chronological eras tell of men like modern barbarians, and not of the infancy of the race. The differentiation of language records a vast period, which has been estimated by philologists at not less than 20,000 years; but at its beginning man was a speaking animal like modern savages, and not the humbler prototype of the human species. So the indications of human antiquity found in the direct products of intelligence would seem to carry the beginning of the race at least 10,000 or 20,000 years or perhaps twice as long into the past.

The geologic evidence of human antiquity is more definite than that yielded by history, written, legendary, and inferred, save that it is not easily reducible to years: A potsherd has been found in the Nile delta overlain by the silt layers (partly counted, partly estimated) of 15,000 annual floods; but, while this relic unquestionably antedates the oldest pyramids, it represents the work of a pottery-maker, as well advanced in the arts as modern savages. Caves and valley gravels of Europe have yielded human bones and works of art indicating the existence of man during and probably before the close of the glacial period, at least in its closing episodes, and the last ice invasion is estimated to have occurred from 7,000 to 50,000 years or more ago; but even then man was in all probability so far developed as to be certainly assignable to the existing species of *Homo sapiens* and had mastered rude arts akin to those of modern savages. The river gravels of this country have been supposed to yield evidence of glacial man, though recent researches, chiefly by our gifted contemporary, Holmes, have shown that the evidence is not conclusive; yet even here there are geologic indications of considerable human antiquity, through the earliest records are of a stone-shaping and fire-using man, and not of a pre-human ancestral form. In many cases the earlier human relics are associated with the remains of animals now extinct or displaced to other areas, of which a considerable number belong to a fauna commonly assigned to the early Pleistocene or the late Tertiary; yet it is to be remembered that the earliest records of human existence tell not of the very beginning of mankind, but of a human form intermediate between modern savages and the higher simians, and more nearly related to man than to any lower form.

THE APOTHEOSIS OF NATURE.

The work of living things.—The living things which abound in the waters and in the air depend directly or indirectly on the earth for support; but at the same time they re-act on the waters, the land, and the air and thereby modify these elements, and thus the character of the earth itself. So the earth is no longer a dying planet made up of simple minerals, but a highly complex body whose superficial portion

represents the joint product of vital, chemical, and physical agencies.

The simple and lowly life-forms of the prime spent their force in assimilating the higher chemic compounds corresponding more or less closely in composition to their own substance; and by virtue of their capacity for assimilation they grew and increased and consumed great quantities of fitly constituted matter and produced great quantities of compounds somewhat higher in the scale of chemic differentiation than those previously existing; and this was the beginning of the transformation of the earth through the agency of living things. So the rocks of the Agnotozoic age, which form some lands of the earth and gave rise to the sediments which formed lands of later birth, are made up in part of biotic compounds, of substances bearing the impress of the action of living things in their composition.

As the chaotic vital force of the beginning assumed a definite direction the living things of the earth increased marvellously in numbers, and at least during some ages and in some parts of the world the seas swarmed with radiates, articulates, and mollusks, as well as lower and simpler organisms; and as time passed some radiates built for themslves stony structures, some articulates developed chitinous frames, and some mollusks secreted semi-stony shells, while certain lower organisms consumed mechanical sediments and transformed them into chemic precipitates; and in this way it is probable that the waters of the ocean were modified and certainly the sediments of the ocean bottom came to be made up in considerable part of the remains of organisms and of complex compounds produced by organic action; and thus the transformation of the earth by living things was carried forward.

As life waxed the endless contest for survival and supremacy among the living things of the earth grew fierce and progressively higher forms were developed. The simple plants of the sea pushed out on the growing land, and in the growth and decay of successive generations transformed the barren rocks into fertile soils made up in part of their own remains and in part of the compounds which they generated. While some of the simple animals of the sea retained their primitive forms, others developed bony armors supported by bony skeletons, and were thereby more perfectly adjusted to their environment, and some dominated the sea, while others pushed out over the land and foraged on the land plants or devoured each other. This was the age of individual might, during which the lower organisms continued to consume and transform simpler chemic compounds, while the higher consumed the lower and raised their composition to still higher grades of complexity, and in this way the lands and the air above the lands, as well as the sea, came to be affected by vital action. Thus the transformation of the earth through the agency of living things was carried forward with ever-increasing rapidity.

As the earth grew old, and the seas shrank, and the continents widened, and as snow and ice gathered about the poles and on the

mountains, the ceaseless struggle for existence among living things raised vitality to a higher plane, and cunning came to prevail over the land and to some extent in the sea; the transformation of lower compounds and lower organisms through consumption by the higher continued, and sea animals and plants pushed up into the rivers and lakes, and after accustoming themselves to sweet waters continued to transform crude earth matter and in turn to supply sustenance to their more exalted foes on the land; meanwhile insects began to fertilize plants and the flora was thereby made to support a more abundant fauna; and insects, birds, and beasts learned to seek or construct shelters from the inclemency of the weather on the ageing earth and thereby to prolong their lives; and thus the transformation of the inorganic earth continued cumulatively, the change of each age being more varied and more rapid than that of the period before.

So the history of the earth from the earliest geologic ages to the advent of man and the beginning of intellect is one of progressing and ever increasing transformation of the materials of the earth; and this process has now gone so far that there are probably no terrestrial materials known to man which have not been modified by vital action, save, possibly, a few ancient crystalline rocks and a few lavas from the deeper sources. Moreover, the history is one of progressively increasing utilization of cosmic forces. Plants and animals are stimulated by light and heat and through these stimuli their activity is multiplied if not generated. Vitality is the flower of the plant which buds in chemic affinity, so that the force of chemism is utilized by all living things. Intellect and cunning, like simple sense-perception, depend on inter-action between bodily substance and environment, and thus every act of organisms in every stage of sense development is a utilization and transformation of cosmic force. Thus, the external earth, the home of man, is the product of long continued vital action, the creature of living things.

The solidarity of life.—Just as the living things of the earth represent a continuous series in which the higher is developed from the lower and in which all are bound together by blood connection, so they represent a mutually inter-dependent series in which few—if any—members could maintain separate existence. The seeds sown on bare rocks can not bring forth plants—they require a soil representing the product of previous plant generations and sometimes the aid of micro-organisms. Even the highest animal—man—perishes when lost in the forest; he can not live without the fire which he has enslaved, the tools which he has made, the lower animals which he has domesticated, the higher plants which he has created by cultivation, hardly without the aid of his kind. In like manner many of the lower organisms depend on the higher; and in the end all living things appear to owe their origin to a primary vitalized magma developed through a peculiar combination of

chemic substances when the condition of the planet was unlike the condition of to-day. So the various living things of the globe, from the lowest to the highest, are inter-dependent.

In so far as living organisms are inter-dependent they re-act on each other and each is modified by its neighbors. Through natural selection and the survival of the fittest in the constant inter-action of vitality, the bee carries pollen from blossom to blossom, whereby the clover is fertilized and made more vigorous, and yields more honey to tempt the bee, and thus the clover is gradually made a honey-yielding plant and the bee a honey-collecting insect, and each gradually modifies the other; the squirrel gathers nuts and hides them in the earth, where some sprout and grow, and thus promotes nut-bearing, and in his search for nuts develops characteristic organs and instincts which increase his chances of survival, and thus the squirrel and the tree co-operate and each modifies the other through a long series of successive inter-actions; and in an endless variety of other ways the living things of the earth inter-act and each modifies the other. So no living thing lives unto himself alone, but each aids or injures his neighbors in an endless succession of inter-actions, and the entire series of living things of the earth is bound together in a single solidarity, and this solidarity of life is the glory of the earth.

The supremacy of man.—The beginning of conquest.—With the advent of man, bestial cunning gave way before intellect, but at the same time bodily organization rose to its highest perfection. It is probable that the supremacy of the human prototype sprang in part from the strength, activity, and adaptability in which the human body rises above the bodies of all other animals. The average man can outrun the average horse in a month, and the trained pedestrian outruns the Arabian courser in a day. The Chinese coolie and Canadian packer bear thrice the loads, in proportion to their weight, that can be borne by oxen. The savage can outclimb the baboon of equal weight, and the civilized sailor can outclimb the savage. The human animal is omnivorous, feeding alike on flesh, fish, and fruit, while the diet of most other animals is limited, and, in addition, the upright posture, the well-developed hands, and powerful arms of the human animal give him immeasurable advantages over the beasts. So mankind may well have risen above other living things in part because of bodily superiority, because the earliest representatives of his type could run, leap, climb, swim, bear burdens, grasp and throw better than their competitors in the struggle for existence. The great superiority of animal man to all other animals is one of the most impressive facts of biology. A few other animals, indeed, exceed him in certain directions, but he competes with all and exceeds most in every direction of bodily exercise, in every physical function, and the perfection of animal development is thus attained in the human body.

possible, if not probable, that the second step toward human
ıtion of the lower world was the discovery and control of fire.
, birds, and insects, build houses, hoard food supplies, lay snares
ıe, plant and cultivate certainly through instinct and probably
h design, and in other ways seek to overcome nature and lift
lves above their environment; but man alone uses fire to protect
l secure comfort, prepare food, take game, and aid generally in
ıjection of nature; so that man may be distinguished, perhaps
ıstly than any other way, as the fire-using animal.
arly step in human development was the use of rude implements
apons, at first, perhaps, after the manner of the apes in crack-
:s, and of monkeys in casting missiles; and thereby through the
development by action, which is an example of the more general
inter-adjustment between the organism and the environment, the
s were taught, the eye was trained, and the various bodily and
faculties were co-ordinated. While the beginning of stone-
g is not definitely known by reason of the imperfection of the
logic record, it would seem to have come up gradually by succes-
inute increments under the Law of Becoming from the use of
pebbles and naturally broken rock fragments; and as shown
American archæologists, Holmes and McGuire, one of the earli-
ns of stone work must have been simple bruising or pecking
to that produced accidentally in cracking nuts or crushing grain.
it is that less initial knowledge and skill are required for stone-
ş than for stone-flaking. Moreover, stone-pecking is produced
nward and inward blows, *i. e.*, by centripetal muscular move-
analogous to those characteristic of all lower animals, of
ver races of man, and of the lower individuals among the
races; while chipping and flaking represent outward blows,
kes away from the individual, or centrifugal muscular move-
ıuch as are not known among the handless animals, rarely found
the four-handed apes and monkeys, uncommon among the lower
: men, and characteristic only of those above the lowest intel-
ranks among the higher races. Thus the earliest industrial arts
to be those acquired in common by man and his higher four-
kindred; they appear to have grown up through stone-pecking,
s within the reach of apes and monkeys, to the highest grade of
aking and chipping, which involves manual skill little lower
at required in diamond-cutting, gold-beating, throwing a thread
he, or file-cutting, the most highly developed operations of en-
ed mechanics.
' bodily strength and skill, by the control of fire, by the devel-
of rude arts borrowed from the higher beasts, and by the
ş of hand and eye, and the co-ordination of faculties through
'e industries, mankind began the conquest of nature and entered
career which has already half transformed the face of the earth.

The conquest of plants.—The savage men of modern times subsist in part on the products of the chase, in part on fruits, nuts, and seeds, and it is probable that primitive men subsisted in a similar way. The higher savages gather and store vegetal products, and barbarous peoples plant hoarded seeds and thereby obtain larger and more certain supplies, and some cultivate the growing plants. In this way certain plants of the earth have been transformed: Wheat, oats, barley, rice, and corn, among the grains; the potato, parsnip, carrot, and several other vegetables of field and garden, and many fruits and berries, together with a number of grasses, have been so far changed by cultivation that they can hardly be traced to their original specific forms; and moreover their original habits of life have been so far transformed that they can not live without human aid: if man were to disappear from the earth, those grains, fruits, and vegetables which he has made to meet his needs could not hold their own in the struggle for existence, but would be swept from the face of the land within a few years. Thus these useful plants are not the creation of natural forces under a natural environment, but are the creatures of mankind, and reflect human needs, human industries, human purposes, human craft.

Certain plants, including different kinds of trees, are useful to man in their natural condition, and these have been preserved; certain other plants are useless or injurious, and these are gradually extirpated or displaced. Now, the process of extermination of useless and injurious plants has been curiously complicated. The primitive tiller of the soil sought to bring his crop to perfection with a minimum expenditure of labor, and at first abandoned and afterwards laid fallow fields overrun by useless plants, or weeds; then he adopted imperfect methods of cultivation, which resulted in the extermination of the weaker individuals among the weeds, and the preservation of the stronger; and thus unconsciously he cultivated useless plants more efficaciously than the useful plants until his fields came to be ridden with weeds; and even yet few farmers realize that there is but one way of coping with weeds *i. e.*, total extermination, and that any less rigid process only increases their vitality, persistence, and pertinacity. But despite this complexity by which the ridding of the world of useless and injurious plants was hindered, the conquest of the plant world has proceeded with ever increasing rapidity; and in many regions only those plants are permitted to grow and yield fruit or substance which make for human welfare or pleasure.

Accordingly the conquest of the plant world by human ingenuity is well under way; the prevailing plants of the earth to-day are those which man has molded to his own liking; of which indeed the seeds were natural, but which he has none the less made, through a long series of operations under the Law of Becoming: certain other plants are preserved by reason of their utility or beauty in natural condition, but the useless and injurious are disappearing from the face of the earth and the future flora will be the handiwork of man.

The conquest of the lower animals.—At first the hand of man was against all other animals, but as his budding intellect expanded and he recognized his superiority he began to capture his ancient enemies for pets and servants, thus reaching the intellectual plane of the ant, which enslaves its kind and keeps kine (in the form of aphides) for their milk; and this was the beginning of the domestication of animals. Before the beginning of written history the cat was kept as a pet, the dog as a companion and slave, the horse and camel as beasts of burden, the cow and sheep as sources of food, and the latter to supply clothing. In early times among barbarous peoples, fowls were kept for their eggs, feathers, and flesh, and the cormorant was trained to take fish and the falcon to capture wild fowls; the elephant was trained as a draft animal or to bear heavy burdens; and in like manner the bee was kept for honey and the silkworm for fiber. Thus a variety of animals were enslaved by man and made to contribute to human welfare and pleasure.

The enslaved animals were modified in various ways: The cat was kept for beauty and docility, and these qualities were cultivated, and thereby the animal was made one of the most beautiful yet cruel, and one of the most docile yet stupid, among the higher animals. The dog was bred for a variety of uses of which many required intelligence, and was thereby made one of the most variable and one of the most intelligent among animals. The cow was bred for flesh, skin, milk, and strength, and has come to yield rich returns in all these products of vitality, but remains one of the most stupid of beasts. The horse was bred for strength, speed, and intelligent responsivity to human will, and has become a noble animal whose neck is clothed with thunder and whose nostrils scent the battle from afar. He has developed a curious intelligence more readily inter-communicable with that of his master than is found in any other animal, mixed with a curious stupidity which renders him a helpless starveling unless he is shod with iron and has carefully prepared food laid before him. The sheep was bred for its flesh or milk, and sometimes for its skin but chiefly for its wool, and has become extraordinarily modified, so that its force is expended in the support of a pilage which has grown into one of the principal sources of dress stuffs of the world; but its intelligence has not been cultivated and it remains timorous, helpless, and hopelessly stupid. The fowl was bred for flesh and eggs and sometimes for feathers, and its flesh has been made palatable and its fertility in eggs has been made one of the most marvellous monstrosities of biology; its feathers have been made to imitate the colors of the rainbow, but its intelligence has been neglected and it remains the incarnation of stupidity. In all these cases and some others the animals have been so completely modified through human instrumentality that their original specific relations can not be traced: in character, in mode of life, in function, they are unlike unto species developed under natural conditions.

In the development of domesticated species man has given heed to his own needs and not to the needs of his four-footed and winged slaves, and thus the characters of his servitors are abnormal if not injurious to the organisms, considered as representatives of animal life. The horse, sheep, and fowl have been made helpless to the extent that they would quickly become extinct without human aid; the cow of civilization, although more self-reliant, could hardly exist without the plants which man has cultivated. Even the dog and cat, the least changed and the most independent of man's four-footed servitors, would find themselves handicapped in the struggle for existence by most of the characters which man has impressed upon them, if mankind were to become extinct. Thus the development of animal characters under domestication is useful not to the species themselves, but only to man.

While a few animals have been enslaved and domesticated for his use, man has looked upon most lower animals as enemies to be destroyed either in the blood-thirsty wantonness born of generations of self-defense or as sources of food, and thus the primitive pre-human or infra-human fauna of the earth is melting away. The stealthy tiger and the kingly lion have been robbed of their domain; the noble buffalo faded at civilization's dawn like frost before the sun; the days of the elephant are numbered unless, indeed, he be preserved by domestication. Men of middle age now living have seen millions of passenger pigeons in single flocks, and hundreds of flocks in a week, but to-day there are hardly enough left to supply the demands of museums; and scores of other species have been exterminated within the period of written history. Thus, in the subjugation of the animals of the earth, men preserve only those that can be enslaved, and all others are slain.

The end of the conquest of the lower animals is not yet, but may easily be foreseen. Man has taken and is yet taking certain animals and molding them to his needs, completely transforming them, creating them according to his will, and all others he is destroying at an ever-increasing rate. The beasts of the pre-human period are disappearing through transformation and through slaughter, and at no distant day the only lower animals of considerable size remaining on the land will be those of human making, literally the creatures of human craft.

The conquest of the under-world.—At first savage men gathered rude pebbles from the brooksides for missiles and for use in cracking nuts and bruising food stuffs; later the pebbles were shaped into rude weapons and implements; and still later fitter rocks were sought in gravel beds, and eventually in the parent ledges of the hill-sides; and this was the beginning of quarrying and mining.

In a later stage of development copper was extracted and beaten into knives, spear-heads, arrow-points, and ornaments for the person; still later iron was collected and wrought. Perhaps the first iron to be used was meteoric, but subsequently ores were gathered from the earth and reduced in crude forges and furnaces, and iron, copper, brass, and

bronze were fabricated and used for an ever increasing variety of utensils, weapons, and implements; and this was the beginning of metallurgy.

At first the fuels were wood, and charcoal made therefrom; but later coal was found, and the work of extracting it from the earth was organized; and with the extraction of coal more varied implements were required, and the use of coal facilitated the fabrication of the metals; and thus coal mining and the extraction and reduction of metals interacted and industries were transformed cumulatively; and so manufacture began.

Primitive men delighted in personal ornaments, and adorned their ears, lips, arms, ankles, and garments with gewgaws. As time passed, and the conquest of the under-world through human ingenuity proceeded, ornaments came to be made of precious metals and gems, and the gewgaws grew into jewelry. So the collection of precious metals and precious stones became an industry, and with the development of proprietary conceptions which grew up with industries, these materials and the articles made therefrom came to possess a special value in the eyes of men and eventually became media of exchange. Thus the search for precious metals and gems was stimulated and commerce was facilitated and industries were developed to the extent that the movements of population and the spread of industries came to be affected by the thirst for gold.

Accordingly, the milestones in the way from savagery to enlightenment are represented by quarries, by the ore beds of iron and other useful metals, by coal mines, and by gold-diggings; but the conquest of each new substance of the under-world gave a new vantage point for further conquest, and thus quarrying and mining, industrial development, and intellectual grasp have inter-acted, each aiding the other, so that progress has been cumulative, and is now under way more rapidly than ever before, and with ever increasing rapidity. To-day nearly all structural materials used in the building of our domiciles and factories, the fuels that transform summer into winter and winter into summer, the illuminants that turn night into day and thus lengthen life, the engines of locomotion on sea and land which unite races and peoples, the media of exchange which bind mankind into a homogeneous mass, are all derived from the under-world, and thereby the condition of man and the face of the earth have been transformed. And within recent years perfumes and flavors like unto those of plants and fruits are derived from the rocks, and one of the most brilliant promises of science is the indication that at no distant day the ingenuity born of earlier conquest will enable men to extract the flower as well as the perfume, the fruit as well as the flavor, from the under-world, so that food may be taken directly from the earth without the intervention of plants and animals.

The conquest of the microcosm.—The most abundant numerically, if not in aggregate volume, among the living things of the earth are the minute organisms of simple structure whose existence can be determined only by means of the high powers of the microscope, or sometimes by their effects on larger organisms. These bacteria are of many varieties, of which most are innocent or useful to the higher organisms, though a few are injurious. Like the higher organisms they are delicately adjusted to their environment, organic as well as inorganic, and thus belong to the great solidarity of living things. During recent years it has been ascertained that the noxious bacteria are causes of disease and death, and the science of bacteria—bacteriology—has been developed for the purpose of controlling or eradicating the maleficent microbes; for thus far the beneficent micro-organisms are commonly neglected in the study of bacteriology. The science of medicine has already been half transformed, half lifted from the plane of empiricism to the plane of exact science; already the plague of old has lost half its terrors and smallpox is under control; cholera is now engaged in its last struggle against human ingenuity and intellect, and many other diseases have been mastered, so that human life is prolonged. So the subjugation of the microcosm, the latest in the series of conquests which anthropology has to record and extol, is well advanced; and the promise for the future is brilliant.

The conquest of the land.—At first the land—like the air and the waters—was common to all living things except in so far as might made right and the stronger displaced the weaker; then men came to dominate over his animal foes and to claim small parts of the earth as his own; and this was the beginning of landed property.

With the multiplication of men and the birth of new industries the property conception was strengthened and the earth came to be parted into kingdoms and fiefs, countries and fields, and still later mining and milling rights grew into existence by a succession of minute increments acting under the Law of Becoming; for this is the mode of cosmic evolution which constrains mankind as well as lower organisms and the inorganic world.

With each discovery of new resources, with each invention or a new mode of conquest, the property conception was strengthened and various institutions came into being; and with each new discovery, each new invention, each higher institution, progress was facilitated so that the conquest of the land, of the plants it yields and the animals it supports, and of the under-earth beneath, is well under way. About one-tenth of all the lands of the earth are now appropriated to human use for fields and domiciles, factories, and highways, and no plants or animals are permitted to remain therein that do not subserve human needs; some three-tenths more of the lands of the earth, with all things pertaining thereto, are more or less perfectly appropriated to human use; and almost all of the remainder, save the mountain tops and the

ice-burdened poles, have become tributary to human needs and pleasures. Moreover, the rivers are bridged, the wilderness is invaded by highways, the deserts are traversed by lines of steel, all inhabited lands are bound into unity by message-bearing wires, while the locomotive annihilates space and the telegraph annihilates time. So human life is prolonged, and progress is promoted more and more successfully every year. Already the conquest of the land has progressed so far that he who will may laugh at the cold, scoff at the storms, and enjoy the products of every part of the earth in whatsoever part thereof he may elect to stay. So completely, indeed, has man modified the land, and so far has the modified land re-acted upon him, that mankind has become his own creature, fitted to civilized life—the highest form of existence ever attained—and no longer adapted to lower conditions. So man has partly made the land, the land has partly made man, and the two great factors in the later development of the earth have interacted cumulatively until each may justly be considered creatures of intelligence, the highest known force of the cosmos.

The conquest of the waters.—Primitive men, like modern savages, sometimes rode on floating logs, and thus caught the spirit of navigation. Then logs were bound by withes and rafting was developed, and thereby the spirit of navigation waxed. As the spirit grew the skill increased; logs were hollowed out by fire and cutting tools, paddles were first improvised and then made, and canoeing was developed. At length the ambition of the primitive navigators outgrew their simple craft of single logs, and the Norsemen and other maritime peoples built larger vessels of many timbers and invented oars, and thus boating began. As ambition and knowledge increased by minute increments under the Law of Becoming the boats pushed out farther and farther from shore and into deeper and deeper waters, and fiercer and fiercer storms were outlived. Long afterward the mariner's compass was invented, and then the stars were studied to the end that the mariner might find his place in the limitless ocean, and so gradually the waters of the earth came to be navigated in all directions. Thus the vitality of the earth, which began in the waters and afterward spread to the land and there attained its highest development, returned to make conquest of the seas, and shipping is now so perfected that the mariner scorns the storm, and seldom falls before its fury.

Even before the advent of man, land animals hunted along the banks of the rivers and shores of the seas that they might find fishes and other aquatic things; and man followed the example of his forerunners and became a fisherman. At first he was fain to confine his operations to brooks and the smaller rivers and peaceful shores; but with the growth of navigation he pushed farther and farther into the deeps, taking all sorts of fishes for food, pearls to ornament his person and serve as media of exchange, oils to keep his lamps alight, and a great variety of other commodities; and to-day a considerable propor-